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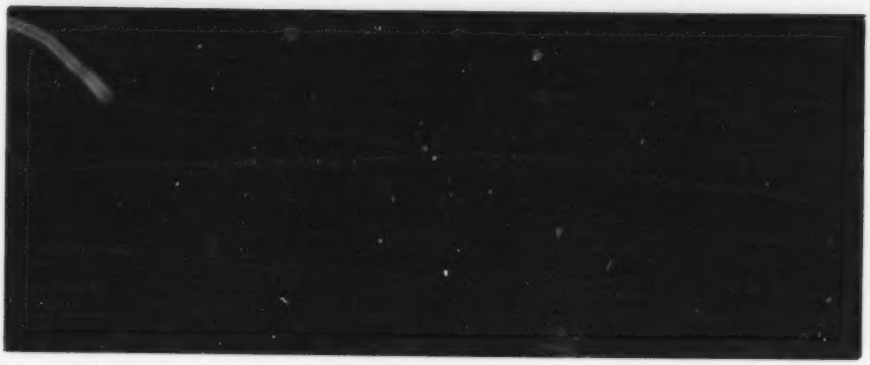

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Dietary Energy and Protein Requirements of Cattle that Differ in Mature Body Size

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DIETARY ENERGY AND PROTEIN REQUIREMENTS OF CATTLE THAT DIFFER IN MATURE BODY SIZE

JOHN MCKINNON AND DR R.D.H. COHEN

DEPARTMENT OF ANIMAL AND POULTRY SCIENCE

UNIVERSITY OF SASKATCHEWAN

EXECUTIVE SUMMARY

91-01790/

S-86-01-0051

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ABSTRACT:

The influence of dietary energy (73.5 or 78.5 % TDN) and crude protein (11, 13 and 15 %) concentration on performance and carcass characteristics of medium (MF) and large (LF) frame steers was studied. The performance of MF steers did not show any beneficial influence of increasing energy or protein level. Slaughter and carcass weights of MF steers were reduced below industry norms on both energy levels. LF steers demonstrated a linear increase in growth with increasing protein concentration ($P < 0.01$). Digestibility results indicate that the improved growth response may result from an increase in the digestibility of dietary energy as crude protein level of the ration increases.

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SUMMARY:

The objective of this work was to evaluate the feedlot performance and carcass characteristics of medium and large frame steers fed diets that vary in energy and protein content. Six rations were formulated to contain one of two energy levels (73.5 and 78.5 % TDN) and one of three crude protein levels (11, 13 and 15 %).

The results of this study indicate that medium frame steers did not show any improvement in performance when fed supplemental energy or protein. The most striking effect of diet was on live weight at slaughter and consequently on carcass weight. Slaughter weight averaged 417 kg. One hundred and thirty one carcasses were price discounted for not weighing within the desired carcass weight range of 256 to 327 kg. These results indicate that the two energy levels used in this study (73.5 and 78.5% TDN) were excessive for the normal growth and development of 272 kg medium frame steer calves and underline the importance of a growing out or backgrounding period prior to placing such calves on high energy finishing rations.

Large frame calves placed directly on finishing rations at or shortly after weaning, responded to both energy and protein supplementation. Calves fed high energy rations throughout the feeding period gained faster and spent an average of 10 days less on feed than those fed the low energy rations. Similarly, performance was improved when crude protein levels were increased above the current National Research Council (1984) recommendation of 11%. Daily gains of large frame calves averaged across energy levels were 1.23, 1.29 and 1.39 kg on the 11, 13 and 15% rations respectively. This improvement in weight gain with increasing protein concentration was significant. Within each energy level, a similar improvement in weight gain was found as protein level increased. Daily gains on the low energy rations averaged 1.18, 1.24 and 1.34 kg on the 11, 13 and 15% protein treatments, respectively. Respective gains on the high energy rations were 1.28, 1.35 and 1.44 kg/day. Carcass characteristics of large frame steers were not significantly effected by diet. Total carcass lean tissue gain was however, greatest for steers fed the high energy, 13% protein treatment.

The results of a digestibility trial indicate that as dietary protein level increased, the digestibility of ration dry matter, crude protein and digestible energy content increased. Nitrogen balance followed a similar pattern. The influence of dietary crude protein level on ration digestibility was more pronounced on low energy rations. These observations indicate that improved growth of large frame steers fed supplemental protein may result from improvement in the digestibility of dietary energy fractions as protein level of the diet increases.

An economic analysis comparing the cost of canola supplementation against the improved growth response of large frame steers was performed. The results indicate that only the animals fed the high energy 13 % protein diet showed a positive return to protein supplementation. Major factors influencing the return to canola feeding were the extent of the improvement in ga level increased and the cost of protein supplementation.

These findings indicate that current dietary energy and crud requirements of medium frame steers are adequate for backgroundi finishing programs. The negative influence of the dietary energy in this study on slaughter and carcass weight, suggest that such placed on a backgrounding program prior to being placed on such f regimes. In contrast, the improved growth of large frame steers f

supplemental energy and crude protein suggests that the crude prote
requirements of such cattle may be underestimated. In light of the
benifit from feeding the high energy, 13% protein diet, it is sugg
further research be conducted to further define the response of su
increasing levels of crude protein.

Appendix:

(C) TALKS AND PAPERS PRESENTED:

(i) Talks - 1987 - Saskatchewan and Alberta Agriculture Meeting Lloydminister, Sk.

Beef Producer meetings at Nipawin, Porcupine Plains and at Baldwinton Sk.

1988 - Beef meetings at Vermillion and Lethbridge Ab.

Saskatchewan Agriculture staff meeting, Saskatoon

Agriculture Institute of Canada, Calgary, Ab.

1989 - Beef Meeting, Turo, NS.

(ii) Papers - Diets For Big Steers. (1987). Cattleman's December issue.

Balancing Frame Size and Protein. (1989). Saskatchewan Cattlefeeders Newsletter.

Dietary Energy and Protein Requirements of Cattle That Differ in Mature Body Size. (1988). Termunde Research Station Beef Report, University of Saskatchewan.

Dietary Energy and Protein Requirements of Cattle That Differ in Mature Body Size. (1988). University of Saskatchewan Research Reports.

Dietary Energy and Protein Requirements of Cattle That Differ in Mature Body Size. (1988). Can. J. An. Sci. (Abstract in press).

(d) See University of Saskatchewan Research Accounts report.

(e) Personnel involved - Research Assistant Ken Koots (70% of time with project).

- Research Associate John McKinnon (100% of time)

(f) No equipment over $500.00 was purchased.

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FINAL REPORT

SUBMITTED TO SASKATCHEWAN AGRICULTURE RESEARCH FUND

PROJECT NAME

DIETARY ENERGY AND PROTEIN REQUIREMENTS OF FEEDLOT CATTLE DIFFERING IN MATURE BODY SIZE

BY

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UNIVERSITY OF SASKATCHEWAN

SASKATOON, SASKATCHEWAN

BACKGROUND AND OBJECTIVES:

Today's cattle population is extremely diverse. There are over forty breeds in use, with many producers utilizing crossbreeding as a means of herd improvement. This genetic diversity has important implications for formulating balanced feedlot rations. For example, compared to the more traditional British breeds, the exotic breeds such as Charolais and Simmental have larger skeletal (frame) size, mature at heavier weights and mature at different rates. In 1984, The National Research Council - National Academy of Science (NRC 1984) recognized these differences in growth between breeds and considered frame size when calculating nutrient requirements for growing and finishing cattle.

There is however, confusion over the adequacy of current crude protein recommendations for large frame cattle. Reports have indicated that the performance of such cattle can be improved when they are fed crude protein levels in excess of current NRC (1984) recommendations. In addition, there is a lack of published evidence concerning crude protein requirements of various biological types of cattle fed rations that vary in energy content.

This study was therefore designed to evaluate the feedlot performance and carcass characteristics of medium and large frame steers fed finishing rations which varied in energy and protein content.

EXPERIMENTAL METHODS:

Two hundred and eighty eight medium and large frame steer calves were randomly assigned by frame size to 24 pens. Six experimental rations were formulated. Each consisted of one of two energy levels (73.5 or 78.5 %) and one of three crude protein levels (11, 13, 15 %). Rations were designated as follows:

1) LL - low energy, low protein;

2) LM - low energy, medium protein;

3) LH - low energy, high protein;

4) HL - high energy, low protein;

5) HM - high energy, medium protein;

6) HH - high energy, high protein;

Throughout the feeding period and at completion of the trial, the following parameters were monitored: biweekly weight change, average daily gain, skeletal size, days to market, feed consumption and feed efficiency. Carcass data obtained through Agriculture Canada's Blue Tag Program included warm weight, fat cover, ribeye area, marbling score, dressing percentage and cutability. Carcass composition was estimated from dissection of randomly selected calves at the start of the experiment and at slaughter from 8 - bone rib samples (4 per pen).

Ration digestibility and nitrogen balance were determined concurrently in a separate feeding trial. Eight steers were blocked by weight and assigned to either the low or high energy rations. Protocol included a 7 day adaptation period, a 7 day period for determination of voluntary intake, a 3 day period

of restricted intake and a 6 day total fecal and urine collection period.

RESULTS AND DISCUSSION:

The forage to concentrate ratio and the chemical composition of the complete rations are presented in Table 1. Canola meal was the supplemental protein in the concentrates (Table 2). The LL treatment was formulated to meet the energy and protein requirements (NRC 1984) of a 317 kg large frame steer gaining 1.36 kg/day and that of a 272 kg medium frame steer gaining 1.13 kg/day.

Medium and large frame sizes were represented by Hereford and Charolais cross steers respectively. All cattle were purchased locally and placed on feed shortly after weaning. Due to differences in response to protein supplementation, the results will be discussed separately for the two frame sizes.

The medium frame steers showed no response to either increasing energy or protein content of the ration. Standard feedlot parameters such as average daily gain, dry matter intake, feed efficiency and days on feed were similar for all diets (Table 3). Carcass characteristics such as weight, ribeye area and cutability were not influenced by diet (Table 4).

The most striking effect of diet on feedlot performance of medium frame steers was the influence of energy level on live weight at slaughter and consequently on carcass weight. Slaughter weight averaged 417 kg. One hundred and thirty-one carcasses were price discounted for not weighing in the desired carcass weight range of 256 to 327 kg. While there was no significant effect of diet on rib composition (Table 4), analysis of the composition of the total weight gain shows a similar negative influence of energy level. Total bone or skeletal growth was reduced ($P < 0.05$) when high energy rations were fed while total fat gain was increased ($P < 0.05$). These results indicate that the two energy levels utilized in this study (73.5 and 78.5 % TDN) were excessive for the normal growth and development of a 272 kg medium frame steer calf and underline the importance of a growing out or backgrounding period prior to placing such cattle on high energy finishing rations.

In contrast, large frame calves responded to both energy and protein supplementation (Table 5). Average daily gain on the low energy rations averaged 1.25 kg versus 1.36 kg on the high energy rations ($P < 0.08$). Averaged across energy levels, daily gain on the 11, 13 and 15 % crude protein treatments was 1.23, 1.29 and 1.39 kg respectively. Regression analysis indicated that this linear effect of protein level on weight gain was significant ($P < 0.01$) (Table 6). However, if one examines the biweekly weight gain, it can be seen that improved growth due to supplemental protein was not evident until day 56 of the trial (Table 6). From that point on, growth rates increased linearly, with increasing dietary protein concentration.

Figure 1 illustrates that a similar linear increase in weight gain was noted when regression analysis was used to examine the effect of protein level within each energy level ($P < 0.07$). Averaged over the trial, daily gains on the low energy treatment were 1.18, 1.24 and 1.34 kg on the 11, 13 and 15 % protein treatments respectively (Table 5). Respective values on the high energy diets were 1.28, 1.35 and 1.44 kg/day (Table 5). It is of interest that the improved response to supplemental protein was seen throughout the feeding period and in particular from day 56 onward. This is in contrast to current NRC (1984) recommendations that allow for a reduction in crude protein content of the diet as the animal enters into the latter stages of growth and fattening.

Dry matter intake was not influenced by energy level, however it did tend to increase with increasing protein content of the ration (Table 5). Feed efficiency tended to improve with the high energy rations ($P < 0.11$) (Figure 2). Large frame steers fed the high energy rations averaged 9 days less on feed than those fed the low energy rations ($P < 0.05$) (Figure 3).

Carcass characteristics of large frame steers were not significantly influenced by increasing energy or protein level. There was however, a trend within the high energy rations to increased carcass lean content with the 13 % crude protein treatment. This is indicated by carcass composition values derived from 8 - bone rib samples (Table 8). Least square means adjusted by analysis of covariance for the influence of grade fat, indicate that ribs from steers fed the high energy, 13% protein ration contained 57.6 % lean and 23.8 % fat. Those from the high energy, 15% protein ration averaged 56% lean and 25% fat, while those from the 11% protein ration had intermediate values. Examination of the composition of the weight gain throughout the trial showed a significant energy by protein interaction with respect to lean tissue (Figure 4). On high energy rations, the 13 % protein treatment resulted in the greatest lean tissue growth, while on the low energy rations this treatment resulted in the least amount of lean gain (Table 7). This discrepancy between energy levels on the response of total lean gain to the 13% protein treatment can be explained by the fact that steers fed the low energy, 13 % protein diet finished at lighter carcass weights. Thus reduced total lean gain throughout the feeding period would be expected as would that of fat and bone.

The digestibility of the dry matter and crude protein fractions and the digestible energy content of the experimental rations were influenced by both energy and protein supplementation (Table 8). A reduction in dry matter digestibility ($P < 0.05$) was noted on diets low in energy and protein (Figure 5). Crude protein digestibility and digestible energy content were increased on the high energy rations and increased linearly with increasing protein concentration of the ration ($P < 0.05$) (Figure 5 and 6). Nitrogen balance, measured as the difference between dietary nitrogen intake and fecal and urinary nitrogen excretion, increased at each level of protein supplementation (Table 8). The effect of crude protein on ration digestibility was influenced by dietary energy level. On low energy rations, an improvement in ration digestibility parameters was seen at each level of supplemental protein. On high energy rations, a plateau was observed at the 13% level, with no further improvement in ration digestibility at the 15% crude protein level.

The results of the digestibility trial may help explain the improved growth response of large frame steers fed supplemental protein over and above that currently recommended (NRC 1984). Increased dietary protein concentration may lead to improved ruminal conditions for digestion of dietary energy fractions. Consequently, the animal would have more energy available for productive functions. This would explain why the response to supplemental protein was seen throughout the trial and in particular from day 56 onward. A second possible explanation for the improvement in growth with increasing dietary protein concentration is a response to bypass protein. As protein concentration was increased, the amount of canola meal fed increased (Table 2). Each level of dietary protein would supply the animal with an increasing level of rumen bypass protein and as a result the total protein nutrition of the animal may have been improved at each level of protein supplementation.

An economic analysis comparing the cost of supplying large frame steers with supplemental protein is given in Table 9. The cost of canola supplementation per steer on low energy rations was $7.62, $16.60 and $38.00 for the 11, 13 and 15 % protein rations respectively. Comparable costs on the

high energy rations were $5.64, $12.57 and $30.67. Based on the actual value of the dressed carcass, the high energy, 13 % protein treatment returned $20.07 per steer as compared to the high energy 11% control. This treatment was the only one to show a net return to canola supplementation. These results may however be somewhat misleading. While they represent the actual values as determined from the data, it should be mentioned that in order to formulate these rations it was necessary to utilize barley from two different sources. For the 11% control rations a barley containing 11.5% crude protein was utilized, while a barley containing 13.5% crude protein was utilized for the higher protein rations. If one formulates all rations using 11.5% barley, then it is necessary to increase the amount of canola meal utilized at the higher protein levels. Under these circumstances, the return to canola feeding for the high energy, 13% protein treatment would be $11.80. In this regard, it is interesting to note that the average crude protein content of Saskatchewan barley as analyzed by the Saskatchewan Feed Test Laboratory for 1986 was 12.0 %.

These results underline the importance of considering the cost of protein supplementation when formulating finishing rations to specific levels of crude protein. In this study supplemental protein levels of 2 and 4 % above current recommendations increased the average daily gain of large frame steers. However, with the exception of the high energy 13% diet, the observed increases in gain failed to offset increased supplementation costs.

CONCLUSIONS:

Dietary energy levels of 73.5 or 78.5 % TDN or greater (dry matter basis) are detrimental to the normal growth and development of 272 kg medium frame steer calves. Currently NRC (1984) recommendations for TDN and crude protein appear adequate for both backgrounding and / or finishing of such cattle. The average daily gain of large frame feedlot cattle was improved by both energy and protein supplementation. The response to supplemental protein was noted on both dietary energy levels.

Energy and protein supplementation improved the digestibility of ration nutrient fractions. In particular, the digestible energy content of low energy rations increased with each level of supplemental protein. This influence of supplemental protein on digestibility may account for the improved growth of large frame steers fed protein in excess of current NRC (1984) recommendations.

These results indicate that current crude protein requirements of large frame cattle may be underestimated. In light of the economic benefit from feeding the high energy 13 % ration, we suggest that further research be conducted to further define the response of such cattle to increasing levels of crude protein.

IMPACT ON INDUSTRY:

These studies indicate to commercial feedlot operators the economic impact of feedlot rations that do not match nutrient content with an animal's growth potential. The response of large frame steers to supplemental protein suggests that the commercial industry may be limiting growth of such cattle by under feeding crude protein. Further research is required to confirm and

further define the growth response of large frame calves to expanded protein levels.

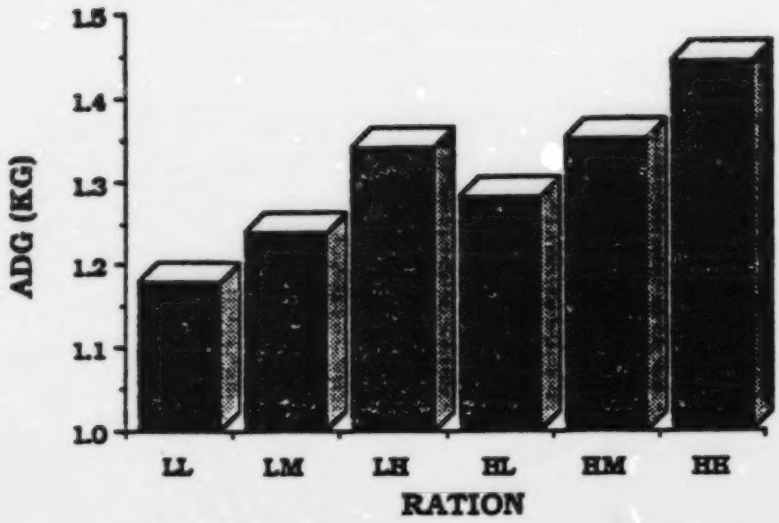


Fig 1. Average daily gain of large frame steers fed low (L=73.5% TDN) or high (H=78.5% TDN) and low (L=11% CP), medium(M=13% CP)or high (H=15% CP) rations.

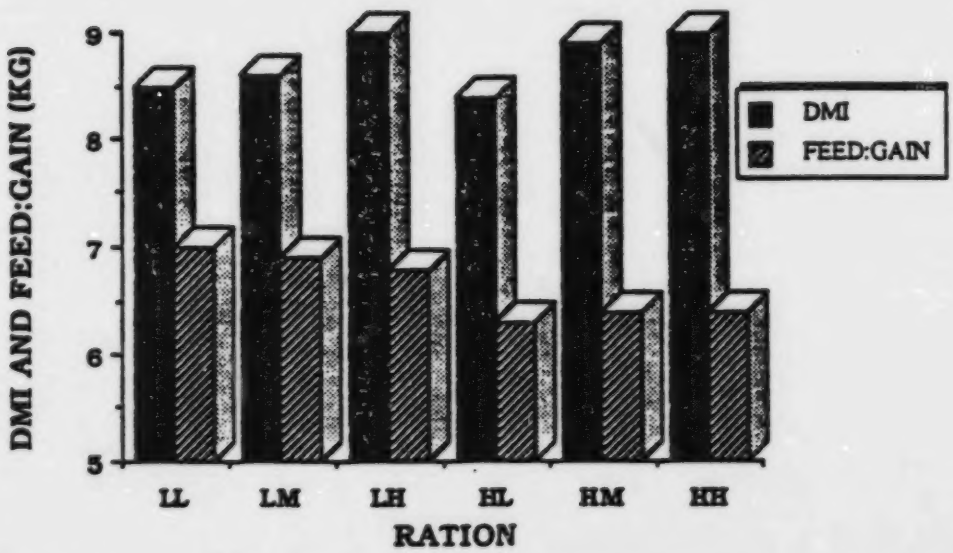
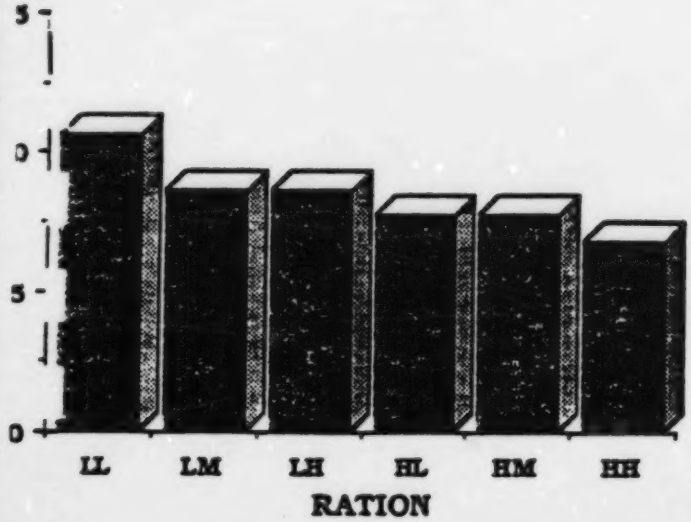


Fig 2. Dry matter intake (DMI kg/d) and feed efficiency (kg feed/kg gain) of large frame steers fed low (L=73.5% TDN) or high (H=78.5% TDN) energy and low (11% CP), medium (13% CP) or high (H=15% CP) rations.



ct of ration on the number of days on feed for large frame steers fed
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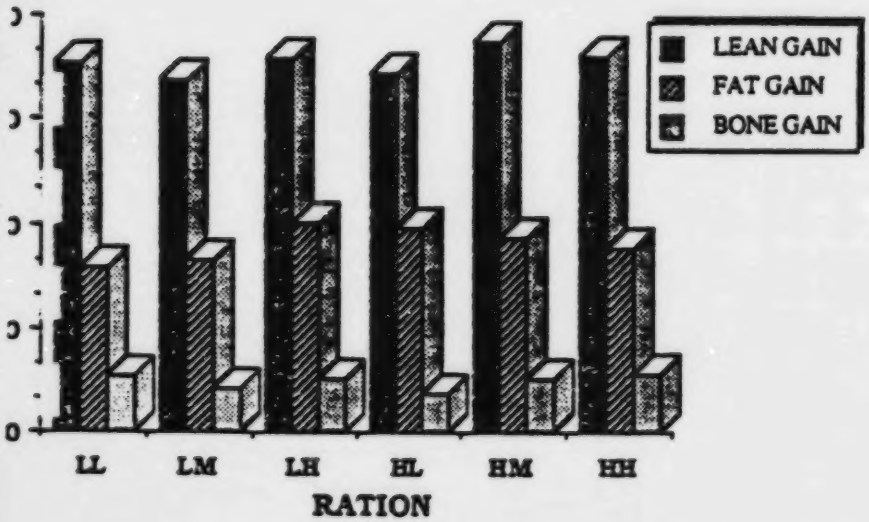

. Effect of dietary energy and protein content on the total weight gain of lean,
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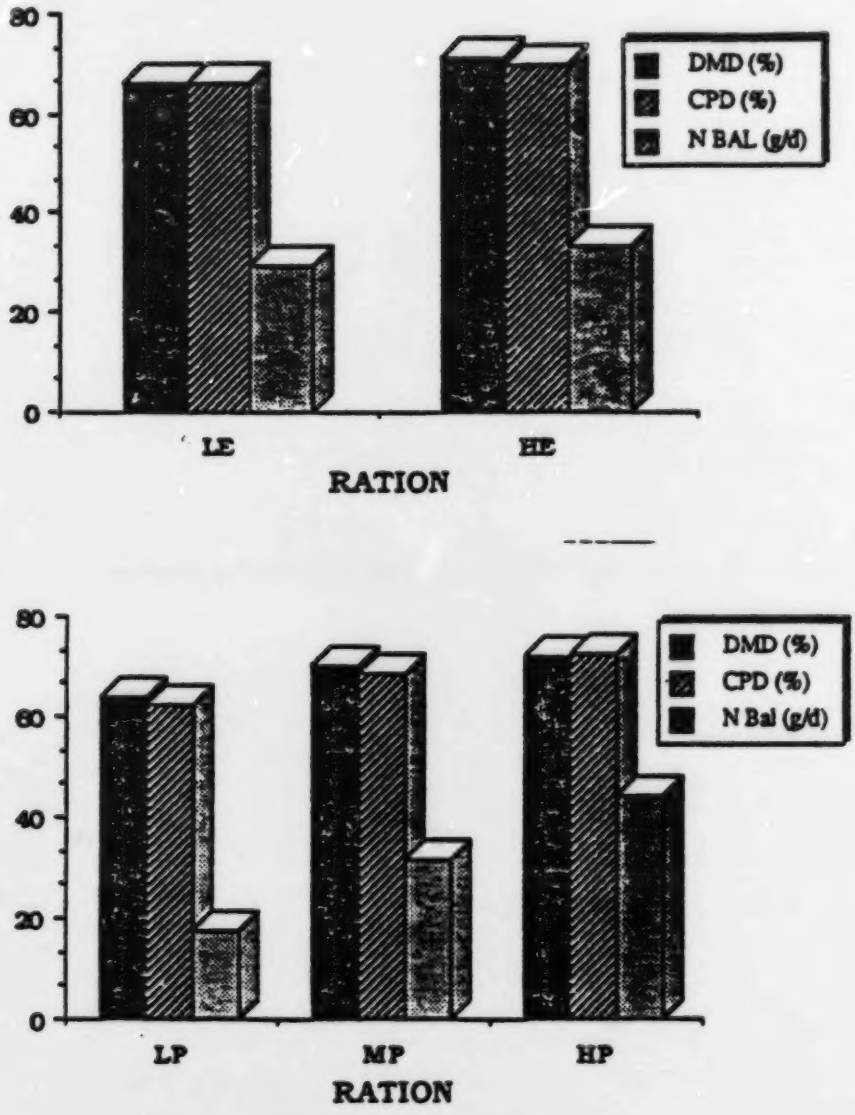

Fig 5. The effect of dietary energy (upper) and protein (lower) on the digestibility of dry matter (DMD%), protein (CPD%) and nitrogen balance (N Bal g/d).

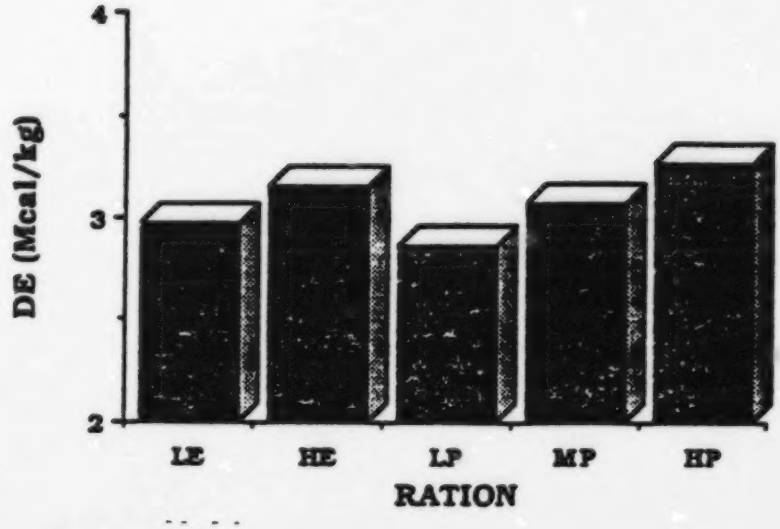

Fig 6. The effect of dietary energy and protein content on the digestible energy content (Mcal/kg) of the ration.

TABLE 1: SILAGE TO CONCENTRATE RATIO AND CHEMICAL ANALYSIS OF EXPERIMENTAL RATIONS (DRY MATTER BASIS).

	Ration					
Item	LL	LM	LH	HL	HM	HH
Silage %	44.0	40.0	36.0	20.0	17.0	13.0
Concentrate %	56.0	60.0	64.0	80.0	83.0	87.0
Chemical Composition %						
Dry matter	46.7	51.7	60.3	64.5	69.6	71.1
Crude protein	11.5	13.1	14.9	11.7	13.2	14.8
TDN[1]	73.5	73.5	73.5	78.5	78.5	78.5
Calcium	1.0	1.1	1.2	1.0	1.1	1.0
Phosphorus	0.6	0.6	0.7	0.6	0.6	0.6

[1]Estimated.

TABLE 2: INGREDIENT COMPOSITION OF CEREAL GRAIN CONCENTRATES.

	Ration					
Item (%)[1]	LL	LM	LH	HL	HM	HH
Barley	83.4	78.1	67.2	88.7	85.6	77.5
Canola	5.0	11.0	22.5	3.0	6.0	14.3
Tallow	5.4	5.2	4.9	3.7	3.7	3.6
Salt	0.9	0.9	0.8	0.6	0.6	0.6
Limestone	2.5	2.4	2.3	2.0	2.1	2.0
Mineral	1.4	1.4	1.3	1.0	1.0	1.0
Vit premix	1.0	1.0	1.0	1.0	1.0	1.0

[1]Dry matter basis.

TABLE 3. INFLUENCE OF DIET ON FEEDLOT PERFORMANCE OF MEDIUM FRAME CALVES.

Item	Ration						
	LL	LM	LH	HL	HM	HH	SE[1]
Initial Wt (kg)	273.30	271.80	274.60	270.40	270.60	272.40	2.2
Final Wt (kg)	421.70	424.80	417.00	417.40	413.40	416.90	2.5
Daily gain (kg)	1.28	1.30	1.28	1.27	1.25	1.29	0.02
D.M. intake (kg/day)	7.60	7.80	7.70	8.10	7.70	7.50	0.2
Efficiency	6.00	6.10	6.10	6.50	6.30	6.00	0.1
Days on feed	119.00	122.00	116.00	119.00	117.00	117.00	0.7

[1]Pooled standard error of the mean.

TABLE 4. INFLUENCE OF DIET ON CARCASS CHARACTERISTICS AND BODY COMPOSITION OF MEDIUM FRAME STEERS.

Item	Ration						
	LL	LM	LH	HL	HM	HH	SE[1]
Carcass Trait							
Weight (kg)	229.9	234.2	227.5	227.4	228.8	233.8	1.4
Ribeye (cm^2)	63.8	66.5	64.5	65.8	66.5	67.1	0.7
Cutability (%)	56.9	57.3	57.0	57.5	57.1	57.3	0.1
Rib Composition (%)							
Lean	55.6	54.9	52.8	53.3	52.8	55.1	0.4
Fat	26.2	26.4	27.8	28.3	28.5	27.9	0.5
Bone	18.2	18.7	19.5	18.4	18.7	17.0	0.2
Total gain (kg)							
Lean*	58.1	60.0	53.7	53.8	55.3	59.1	0.7
Fat [2]*	23.8	25.2	23.5	26.7	26.1	28.3	0.3
Bone[2]*	7.3	9.1	8.8	7.7	8.1	6.1	0.2

[1]Pooled standard error of the mean.

[2]Significant effect of energy level ($P < 0.05$).

*Energy*protein interaction ($P < 0.05$).

TABLE 5. INFLUENCE OF DIET ON FEEDLOT PERFORMANCE OF LARGE FRAME CALVES.

Item (kg)	Ration						
	LL	LM	LH	HL	HM	HH	SE[1]
Initial Wt	323.00	323.30	322.10	320.20	323.10	324.10	2.3
Final Wt	505.40	498.20	508.00	497.00	511.10	511.40	3.4
Daily gain[2]	1.18	1.24	1.34	1.28	1.35	1.44	0.02
D.M. intake	8.50	8.60	9.00	8.40	8.90	9.00	0.2
Efficiency	7.00	6.90	6.80	6.30	6.40	6.40	0.1
Days on feed	153.00	143.00	143.00	139.00	139.00	134.00	1.5

[1]Pooled standard error of the mean.

[2]Linear effect of protein across energy levels ($P < 0.001$).

Linear effect of protein within energy level ($P < 0.07$).

TABLE 6. BIWEEKLY GROWTH RATES OF LARGE FRAME STEERS FED DIETS THAT VARY IN CRUDE PROTEIN CONTENT (KG / DAY).

	Ration[1]				
Interval	LL	LM	LH	SE[2]	P > T
Day 14	1.18	1.37	1.33	0.04	0.40
Day 28	1.29	1.40	1.34	0.03	0.45
Day 42	1.25	1.31	1.32	0.02	0.31
Day 56	1.28	1.39	1.42	0.02	0.01
Day 70	1.24	1.34	1.43	0.02	0.001
Day 84	1.30	1.42	1.51	0.02	0.001
Day 98	1.29	1.35	1.43	0.02	0.01
Overall	1.23	1.29	1.39	0.02	0.001

[1]Values averaged over both energy levels.

[2]Pooled standard error of the mean.

TABLE 7. INFLUENCE OF DIET ON CARCASS CHARACTERISTICS AND BODY COMPOSITION OF LARGE FRAME STEERS.

Item	Ration						
	LL	LM	LH	HL	HM	HH	SE[1]
Carcass Trait							
Weight (kg)	283.0	278.6	291.3	283.6	292.3	288.7	3.3
Ribeye (cm^2)	82.6	84.5	83.9	85.8	86.5	82.6	0.8
Cutability (%)	59.9	59.8	59.7	60.1	60.0	59.6	0.1
Rib Composition (%)							
Lean	57.3	58.1	56.8	57.0	57.6	56.0	0.4
Fat	23.4	23.4	24.6	25.4	23.8	25.0	0.4
Bone	19.4	18.5	18.5	17.7	18.5	19.0	0.1
Total gain (kg)							
Lean*	71.2	67.8	72.1	68.9	75.4	72.2	1.0
Fat [2,3*]	31.7	33.3	40.4	39.4	37.4	35.7	0.5
Bone [3*]	11.1	8.4	10.2	7.8	10.6	11.3	0.3

[1]Pooled standard error of the mean.

[2]Significant effect of energy level ($P < 0.05$).

[3]Significant protein effect ($P < 0.05$).

*Energy*protein interaction ($P < 0.05$).

TABLE 8. INFLUENCE OF ENERGY AND PROTEIN LEVEL ON DRY MATTER AND CRUDE PROTEIN DIGESTIBILITY, DIGESTIBLE ENERGY CONTENT AND NITROGEN BALANCE.

	Treatment[2]					
	Energy		Protein			
Item	L	H	L	M	H	SE[1]
Digestibility Coefficient (%)						
Dry Matter[3]	66.50[a]	71.00[b]	63.90[a]	70.10[b]	72.20[b]	1.1
Crude Protein	66.20[a]	69.90[b]	62.40[a]	68.70[b]	72.90[c]	1.3
Dig. Energy[3] (Mcal/kg)	2.98[a]	3.16[b]	2.87[a]	3.07[b]	3.26[c]	0.05
Nitrogen Balance[3] (g/day)	29.40	33.40	17.70[a]	31.90[b]	44.40[c]	2.9

[1]Standard error of the mean.

[2]abc, means with different superscripts within treatment significantly different ($P < 0.05$).

[3]Energy * protein interaction ($P < 0.05$).

Table 9: Influence of added protein on financial returns[1].

	Ration					
Item	LL	LM	LH	HL	HM	HH
Canola intake (kg/day/steer)	0.27	0.63	1.44	0.22	0.49	1.24
Canola cost[2] (steer/trial)	$7.62	$16.60	$38.00	$5.64	$12.57	$30.67
Carcass value ($3.17/kg)	$ 898.00	$884.00	$925.00	$900.00	$927.00	$917.00
Return to Canola Feeding ($/Steer)	NA	-$9.00	-$3.38	NA	+$20.07	- $8.00

[1]Data based on large frame steers only.

[2]Canola value = $180.00 per tonne.

3-84-32

Executive Summay Report

Fertilizer Requirements of Grazed Seeded Grass Pastures and the Effects on Nutrition and Production of Beef Cattle.

by: R.D.H. Cohen

Department of Animal and Poultry Science

University of Saskatchewan, Saskatoon S7N 0W0

Four levels of nitrogen fertilzer (0, 50, 100 and 200 kg N/ha) were applied to two 2 ha replications of a 32 year old bromegrass/crested wheatgrass pasture in each of three years. Measurements were made on pasture production, quality and utilization by grazing heifers and also on animal production and number of grazing days.

Pasture dry matter production was increased by approximately 40 percent by fertilizer application and maximised at 100 kg N/ha in a wet year, 1983, and at 200 kg N/ha in a dry year, 1984. The number of animal grazing days and total liveweight production increased by up to 76% and 113% respectively at 200 kg N/ha in all years. The application of fertilizer greatly condensed the pasture growing season but this effect was greatest in a wet year compared with a dry year.

Pasture crude protein, copper and iron contents increased with increasing fertilizer application but fertilizer did not influence any other quality factors. Pasture protein digestibility, phosphorus and potassium declined with pasture maturity while calcium, zinc and iron increased with maturity. Evidence of nutrient deficiencies for pregnant heifers was apparant for crude protein and copper on all unfertilized pastures but not

on fertilized pasture, phosphorus was deficient on all pastures, particularly as they matured and more so in a dry year. High levels of iron in the pasture may interfere with the metabolism and absorption of other minerals such as phosphorus, copper, zinc, manganese, cobalt and selenium. There was also evidence that high levels of nitrogen fertilization may increase the risk of grass tetany, particularly during the first 28 days of grazing.

There was some accumulation of nitrogen in the soil at 0.15 and 15-30 cm with increasing fertilizer application but nitrogen fertilizer did not influence soil phosphorus, potassium or sulfur. Soil phosphorus levels were inadequate for maximum pasture production but potassium and sulfur levels were always adequate.

The results of this experiment suggest that current pasture fertilizer recommendations of 35-100 kg N/ha are inadequate for maximum beef production on this soil type.

Fertilizer Requirements of Grazed Seeded Grass Pastures and the Effects on Nutrition and Production of Beef Cattle.

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Abstract

Four levels of nitrogen fertilzer (0, 50, 100 and 200 kg N/ha) were applied to two 2 ha replications of a 32 year old bromegrass/crested wheatgrass pasture in each of three years. Measurements were made on pasture production, quality and utilization by grazing heifers and also on animal production and number of grazing days.

Pasture dry matter production was increased by approximately 40 percent by fertilizer application and maximised at 100 kg N/ha in a wet year, 1983, and at 200 kg N/ha in a dry year, 1984. The number of animal grazing days and total liveweight production also increased linearly with increasing fertilizer application ($P < 0.05$) and both parameters were maximised at 200 kg N/ha in all years. The application of fertilizer greatly condensed the pasture growing season but this effect was greatest in a wet year compared with a dry year.

Pasture crude protein, copper and iron contents increased with increasing fertilizer application ($P < 0.05$) but fertilizer did not influence any other quality factors. Pasture protein,digestibility, phosphorus and potassium declined with pasture maturity ($P < 0.05$) while calcium, zinc and

iron increased with maturity ($P < 0.05$). Evidence of nutrient deficiencies for pregnant heifers was apparant for crude protein and copper on all unfertilized pastures but not on fertilized pasture. Phosphorus was deficient on all pastures, particularly as they matured and more so in a dry year. High levels of iron in the pasture may interfere with the metabolism and absorption of other minerals such as phosphorus, copper, zinc, manganese, cobalt and selenium. There was also evidence that high levels of nitrogen fertilization may increase the risk of grass tetany, particularly during the first 28 days of grazing.

There was some accumulation of nitrogen in the soil at 0-15 cm and 15-30 cm with increasing fertilizer application ($P < 0.05$) but nitrogen fertilizer did not influence soil phosphorus, potassium or sulfur. Soil phosphorus levels were inadequate for maximum pasture production but potassium and sulfur levels were always adequate.

The results suggest that current pasture fertilizer recommendations of 35-100 kg N/ha are inadequate for maximum production.

Background and Objectives

Grazed pasture is a valuable resource for the cattle industry in Saskatchewan and the indications are that this resource is being inefficiently utilized. Inadequate soil nitrogen levels restrict both plant growth and nutritive value, thereby reducing carrying capacity and consequently the amount of beef produced from these pastures.

The objectives of this project are to determine the responses of grazed pastures to applications of nitrogen fertilizer; to determine the effects of nitrogen fertilization of grazed pasture on beef cattle production; to

determine the effect of nitrogen fertilizer on the efficiency of utilization of grazed pasture.

Experimental Method

The study began in the spring of 1983 with four levels of nitrogen fertilizer (0, 50, 100, 200 kg N/ha) applied annually to two 2 hectare replications of a 32 year old brome/crested wheatgrass pasture. The pastures were stocked in spring each year with pregnant yearling beef heifers. Animal production was determined using a 'put and take' grazing system. Test animals, stocked at 2.5 heifers/ha were used for liveweight gain calculations and additional 'put and take' animals were incorporated into the total liveweight production (TLP) calculations.

Every two weeks the heifers were weighed and pasture quality, availability and utilization determined. Blood samples were collected throughout the grazing season and the mineral status of the cattle will be related to forage mineral levels. Daily precipitation was recorded from April 1 until termination of grazing. Soil samples were taken at the beginning and end of the grazing season in order to investigate the residual effects of fertilizer treatment on soil fertility. Pasture utilization will be related to pasture production and quality, pasture production will be related to soil fertility and fertilizer application rates and animal productivity will be related to all of these parameters.

Results and Discussion

Precipitation from April 1 to August 30 was 330, 110 and 298 mm for 1983, 1984 and 1985 respectively. The mean precipitation for the trial site

is 217mm.

Pasture and Animal Production

Productivity, as measured by total forage production (TFP), animal grazing days (AGD) and total liveweight production (TLP), increased with increasing fertilizer rates ($P < 0.05$; Figures 1,2 and 3). Analysis of the 1983 data indicated that TFP increased from 3976 kg/ha at 0 kg N/ha to a maximum of 5687 kg/ha at 100 kg N/ha, AGD increased from 159 days/ha at 0 kg N/ha to a maximum of 292 days/ha at 200 kg/N ha and TLP increased from 115 kg/ha at 0 kg N/ha to a maximum of 200 kg/ha at 150 kg N/ha. In 1984 a reduction in pasture productivity was observed as a result of low precipitation with the maximum TFP (3094 kg DM/ha), AGD (154 days/ha) and TLP (122 kg/ha) all occurring at 200 kg N/ha. In 1985 maximum AGD and TLP again occurred at 200 kg N/ha (265 days/ha and 176 kg/ha respectively).

The application of fertilizer greatly condensed the pasture growing season but this effect was also influenced by rainfall. For example, in 1983, a high rainfall year, 78% of the total pasture growth had occurred by the first day of grazing (June 27) where 200 kg N/ha had been appplied but only 30% where no fertilizer had been applied. In 1984, a dry year, grazing commenced on June 20 and by then 100% and 88% of total pasture growth had occurred where 200 and 0 kg N/ha had been applied. Thus, when fertilizer is applied, these pastures should be heavily grazed early in the season irrespective of rainfall but this recommendation may only apply to unfertilized pastures in a dry year.

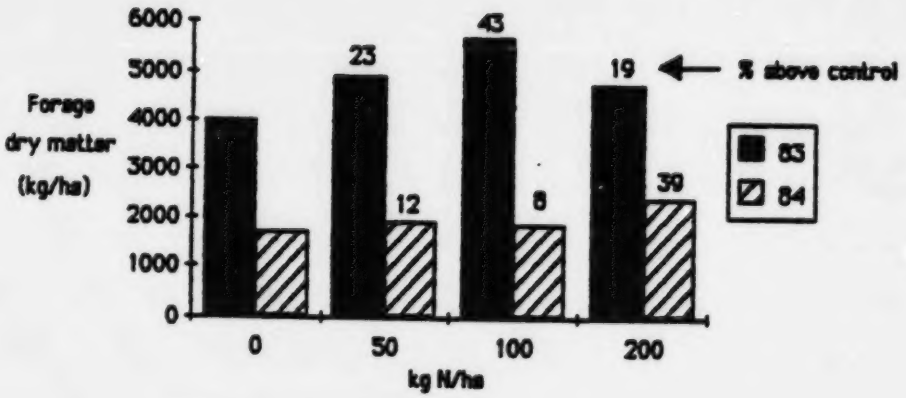

Figure 1. The effect of nitrogen fertilizer on total forage production.

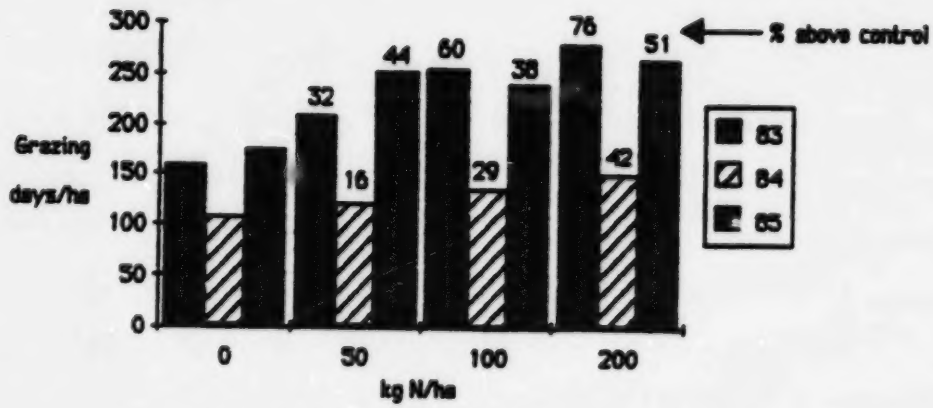

Figure 2. The effect of nitrogen fertilizer on animal grazing days.

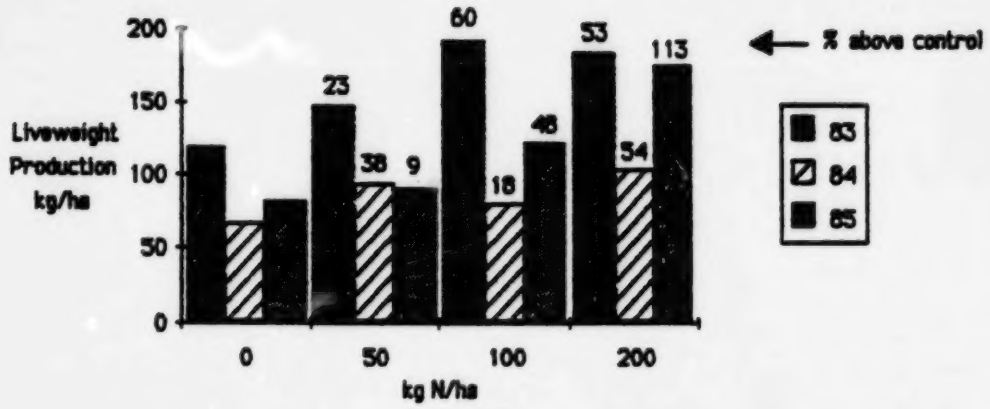

Figure 3. The effect of nitrogen fertilizer on total liveweight production.

Nutrition of Grazing Cattle

Pasture crude protein (CP) content increased with nitrogen fertilizer application rates ($P < 0.05$), but declined throughout the grazing season at all fertilizer rates ($P < 0.05$, Figure 4). The CP requirements for pregnant heifers were met throughout the grazing season for the 100 and 200 kg N/ha treatments but by the end of the grazing season they were marginal at the 50 kg N/ha and deficient at the 0 kg N/ha treatments. The increase in pasture quality, with increasing fertilizer application, as indicated by increasing CP levels, is reflected in the decreasing amount of forage required per unit of liveweight produced (Figure 5).

Nitrogen fertilizer did not influence organic matter digestibility (OMD) but OMD declined throughout the grazing season.

$$OMD = 66.52 - 0.80\,D + 0.01\,D^2 \quad (R = 0.88;\ RSD = 3.14;\ P < 0.01)$$

where D is the number of days after the first day of grazing.

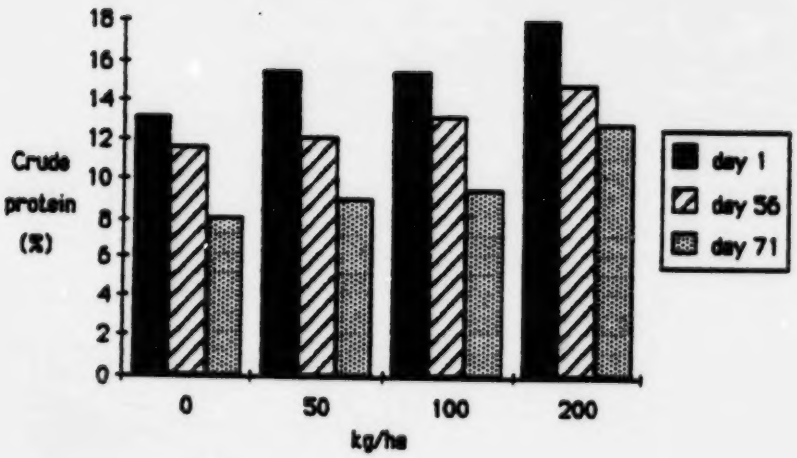

Figure 4. The effect of nitrogen fertilizer on forage crude protein content.

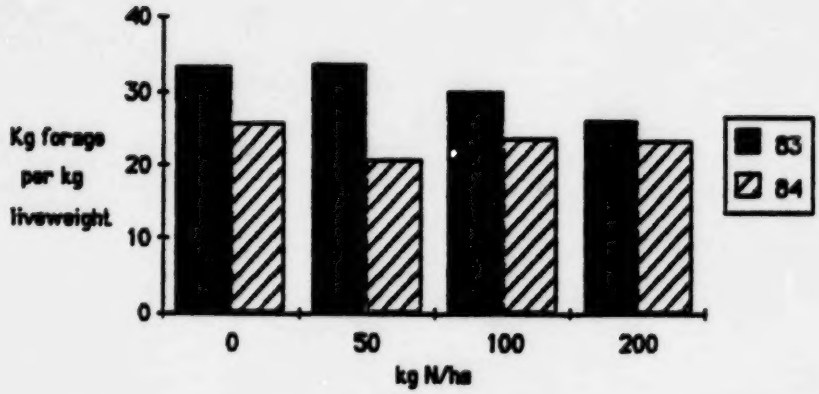

Figure 5. The effect of nitrogen on feed utilization ratio (kg forage eaten/kg liveweight gain)

Several very interesting effects of nitrogen fertilizer application on pasture mineral content have also been recorded. For example, nitrogen fertilizer increased the pasture copper content ($P < 0.05$), although copper levels were only increased from deficient to marginal. Similarly, pasture iron levels were increased by nitrogen fertilizer ($P < 0.05$) but in this case the iron levels were extremely high (between 1100 and 1800 ppm) and such high levels may interfere with the absorption and metabolism of other minerals such as phosphorus, copper, zinc, manganese, cobalt and selenium.

Nitrogen fertilization did not influence the concentration of any of the other minerals. However concentrations of phosphorus and potassium declined while those of calcium, zinc and iron increased with maturity ($P < 0.05$). The decline in phosphorus content was more severe in the dry year, 1984, when levels fell well below NRC recommendations.

The application of nitrogen fertilizer to pastures may also increase the risk of grass tetany. Grass tetany has been related to the ratio of K to Ca + Mg in the herbage. If the grass tetany ratio (GTR) increases above 2.0 the risk of grass tetany increases. Nitrogen fertilizer (Nkg/ha) significantly increased the GTR,

$$GTR = 1.86 + 0.002\ N \quad (R = 0.74;\ RSD = 0.14;\ P < 0.05)$$

and the GTR exceeded 2.0 at 70 kg N/ha. Furthermore, the GTR is related to advancing plant maturity (D days),

$$GTR = 2.64 + 0.02\ D - 0.002\ D^2 \quad (R = 0.98;\ RSD = 0.15;\ P < 0.01)$$

which suggests that the risk of grass tetany is high in the first 28 days of grazing, particularly at high rates of nitrogen fertilizer application.

Soil Fertility

There were no differences in soil nitrogen levels between the four fertilizer applications in fall 1983, indicating that all the fertilizer nitrogen had been either used by the plant or lost through leaching or volatilization. In fall 1984, however, there was some accumulation of soil nitrogen at 0-15 cm depth ($P < 0.05$) indicating some residue fertilizer, probably due to the low rainfall during the 1984 grazing season. Soil nitrogen accumulation below a soil depth of 15 cm occurred only at the highest rate of fertilizer application ($P < 0.05$). Nitrogen fertilizer did not influence soil phosphorus, potassium or sulfate-S levels. Soil P levels, 6.75 at 0.15 cm, were deficient for maximum pasture production but K and S levels were always adequate (2.20 µg/g and 5.2 µg/g respectively at 0.15 cm).

Impact

Laboratory analysis of the various samples taken have not been completed, therefore, a complete analysis of the relationships between fertilizer application, utilization and livestock production is not yet possible. The study has so far provided data on the effects of nitrogen fertilization of grazed pasture during two above average rainfall years and one drought year. Results clearly indicate the dependency of this type of study on seasonal conditions. At least five years of data are required before these results can be assessed in terms of real biological or economic terms. However, the indications from the study suggest that current pasture fertilizer recommendations of 35-100 kg N/ha are insufficient for maximum beef production on this soil type.

3-83-81

FERTILIZER REQUIREMENTS OF GRAZED SEEDED GRASS PASTURES AND THE SUBSEQUENT EFFECTS ON NUTRITION AND PRODUCTION OF BEEF CATTLE AND SUBSEQUENT PERFORMANCE ON WINTER FEED

R.D.H. Cohen and S.B.M. Wright

Grazed pasture is a valuable resource for the cattle industry in Saskatchewan and the indications are that this resource is being inefficiently utilized. Inadequate soil nitrogen levels restrict both plant growth and nutritive value, thereby reducing carrying capacity and consequently the amount of beef produced from these pastures. This project will investigate the economic viability of pasture fertilization and the accompanying increase in pasture productivity.

Four levels of nitrogen fertilizer (0, 50, 100, and 200 kg N/ha) were applied annually to two replicates of a 32 year old brome (Bromus inermis)/ crested wheatgrass(Agyropyron cristatum) pasture. The two hectare pastures were grazed by minimum of five pregnant yearling heifers in a put and take stocking system.

Soil samples collected before fertilization and at the end of each of two grazing seasons showed an increase in surface soil nitrogen with increasing fertilizer rates only following the second grazing season. Soil nitrogen accumulation below a soil depth of 15 cm occurred only at the highest fertilizer rate. Every two weeks the heifers were weighed and pasture quality, availability and utilization determined.

A reduction in pasture productivity was observed in the second year as a result of low precipitation. In 1983, the number of animal grazing days (AGD), total forage production (TFP), and total liveweight production (TLP) increased curvilinearly with increasing fertilizer application. Pasture quality also increased with increasing fertilizer rates as is indicated by a linear decline in the forage required per unit liveweight produced. Maximum AGD (292 days/ha) occurred at 200 kg N/ha, TFP (5659 kg DM/ha) at 120 kg N/ha, and TLP (200 kg/ha) at 150 kg N/ha. In 1984 all productivity measurments tended to increase in linear fashion with the maximum AGD (154 days/ha), TFP (3094 kg DM/ha), and TLP (122.1 kg/ha) all occurring at 200 kg N/ha.

FERTILIZER REQUIREMENTS OF GRAZED SEEDED GRASS PASTURES AND THE EFFECTS ON NUTRITION AND PRODUCTION OF BEEF CATTLE AND SUBSEQUENT PERFORMANCE ON WINTER FEED

R.D.H. Cohen and S.B.M. Wright

Dr

ABSTRACT

Four levels of nitrogen fertilizer (0, 50, 100, and 200 kg N/ha) were applied annually to two replicates of a 32 year old brome (*Bromus inermis*)/ crested wheatgrass(*Agyropyron cristatum*) pasture. The two hectare pastures were grazed by minimum of five pregnant yearling heifers in a put and take stocking system.

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BACKGROUND AND OBJECTIVES

Grazed pasture is a valuable resource for the cattle industry in Saskatchewan and the indications are that this resource is being inefficiently utilized. Inadequate soil nitrogen levels restrict both plant growth and nutritive value, thereby reducing carring capacity and consequently the amount of beef produced from these pasture lands. While McCartney and Robertson (1982) have indicated that fertilizer applications of 90 kg N/ha are economic on depleted community pastures in Northern Saskatchewan, their experiments with a single level of nitrogen fertilizer do not allow for the assessment of biological and economic optima for fertilizer use.

The objectives of this project were:

1) To determine the biological and economic responses of grazed pastures to applications of nitrogen fertilizer.

2) To determine the effects of nitrogen fertilization of grazed pasture on beef cattle production.

3) To determine the effect of nitrogen fertilizer on the efficiency of utilization of grazed pasture.

EXPERIMENTAL METHOD

This study commenced in spring 1983 with four levels of nitrogen fertilizer (0, 50, 100, 200 kg N/ha) applied annually to two 2 hectare replications of a 32 year old brome (*Bromus inermis*)/crested wheatgrass (*Agyropyron cristatum*) pasture at the Termuende Research Station, Lanigan. The pastures were stocked each spring with pregnant yearling beef heifers. Animal production was determined using a 'put and take' grazing system. Tester animals stocked at 2.5 heifers/ha were used for liveweight gain calculations and additional 'put and take' animals were incorporated into the total liveweight production calculations using the following formula:

$$\text{TLP(kg/ha)} = \frac{\text{Av. daily gain x no. of animal grazing days per pasture}}{\text{2 hectares per pasture}}$$

The experimental animals were weighed every two weeks and on alternate weeks measurments of forage quality, availability and utilization were obtained by sampling inside and outside of six exclosure cages in each pasture. Laboratory analysis of clipped pasture was undertaken to compare with analysis of grazed herbage collected from heifers fistulated at the esophagus. Samples were analyzed in the laboratory for *in-vitro* digestibility, protein, calcium, phosphorus, magnesium, sulphur, copper, molybdenum, iron, and manganese. Pasture intake was determined in year two using Cr_2O_3 as a marker for fecal output and *in-vitro* digestibility estimates from esophageal extrusa samples.

Blood samples were collected throughout the grazing season and the mineral status of the cattle will be related to forage mineral levels. Daily precipitation was recorded from May 1 to the termination of grazing. Soil samples were taken at the beginning and end of the grazing season in order to investigate the residual effects of fertilizer treatment on soil fertility.

RESULTS AND DISCUSSION

The data reported are preliminary and should be interpreted with caution.

Season grazing terminated after 71 days in 1983 and after only 42 days in 1984 due to severe drought conditions. Precipitation from May 1 to the end of the grazing season in 1984 (August 1), was 110.1 mm compared to 219.0 over the same period in 1983. While the data for 1984 provide useful information for a drought year, little useful general extrapolation can be attempted.

Productivity as measured by animal grazing days (AGD), total forage production (TFP) and total liveweight production (TLP) generally increased with increasing fertilizer rates (Table 1). Regression analysis of the 1983 data indicated that AGD increased from 159 days/ha at 0 kg N/ha to a maximum of 292 days/ha at 200 kg N/ha; TLP increased from 115 kg/ha at 0 kg N/ha to a maximum of 200 kg/ha at 150 kg N/ha and TFP increased from 3900 kg/ha at 0 kg N/ha to a maximum of 5650 kg/ha at 120 kg N/ha. Crude protein content (CP) on a percentage of dry matter baisis also increased with increasing nitrogen fertilizer application rates (X kg N/ha). The relationship on day 1 of the grazing season was described by the linear equation;

$$CP = 13.477 + 0.027X \quad (R = 0.985;\ RSD = 0.9681;\ P<0.01) \qquad (1)$$

Maximum CP level (18.02%) occurred at 200 kg N/ha. The linear relationship continued throughout the grazing season such that on day 71, the relationship was:

$$CP = 7.8 + 0.24X \quad (R = 0.87;\ RSD = 1.16;\ P<0.01) \qquad (2)$$

With a maximum CP level (12.7) at 200 kg N/ha. Crude protein levels declined throughout the grazing season as indicated by equations 1 and 2. Crude protein requirements for pregnant heifers were met throughout the grazing season for the 100 and 200 kg N/ha treatments but by the end of the grazing season they were marginal for the 50 kg N/ha and deficient at the 0 kg N/ha treatment. The increase in nutrient value as indicated by increasing CP levels is clearly reflected in the decreasing ratio of kg forage : kg liveweight seen in table 1.

Analysis of Ca, P, and Cu showed no effect due to fertilizer. Mean seasonal values for Ca, P, and Cu were 0.59%, 0.17%, and 7.49 ppm respectively. These values are adequate for optimum production from pregnant heifers for Ca, but inadequate for P and Cu.

In 1984 AGD, TLP, and TFP did not show the curvilinear increases of the 1983 grazing season but rather a tendency towards linear increases with increasing fertilizer rates (table 1). The 1984 data are more variable than the previous year primarily due to the reduced precipitation. AGD increased linearly with fertilizer aplication rate and was best described by the equation;

$$AGD = 110.3 + 0.22X \quad (R = 0.92;\ RSD = 7.99;\ P<0.01). \qquad (3)$$

The maximum AGD 154 days/ha) were obtained at 200 kg N/ha.

The relationship between TFP and fertilizer rate was also linear but not signifigant:

$$TFP = 1706 + 3.2X \quad (R = 0.94;\ RSD = 125.1;\ P>0.05) \qquad (4)$$

Variation within treatment was high and this relationship was based on treatment means. Actual TFP ranged from 1714 kg Dry Matter/ha on the control pastures to 3094 kg/ha on one of the 200 kg/ha replicates.

Total liveweight was also variable within treatment. TLP increased linearly with fertilizer application, though again this was non-signifigant;

$$TLP = 72.9 + 0.15X \quad (R = 0.82;\ RSD = 11.19;\ P>0.05). \qquad (5)$$

TLP ranged from 76.6 kg/ha to 122.1 kg/ha on the control and 200 kg N/ha respectively.

Analysis of soil samples during spring 1983, prior to fertilizer applicaton and fall 1983, after removal of the heifers indicated little residual fertilizer nitrogen at any of the fertilizer levels throughout the 0-60 cm soil zone. In the fall of 1984 however, residual levels of

fertilizer nitrogen increased with increasing fertilizer application levels. Although increases were evident throughout the 60 cm soil profile, nitrogen accumulation was only apparent below 15 cm in the 200 kg N/ha fertilizer treatments (table 2).

In both years, nitrogen fertilizer did not influence soil phosphorus, potassium or sulphate-S levels. Soil phosphorus levels (6.75 ug/g at 0-15 cm) were deficient for maximum pasture production while potassium (220 ug/g) and sulphate-S (5.2 ug/g) at 0-15 cm were adequate for maximum pasture production.

Laboratory analysis of pasture, fistula, fecal and plasma samples are not yet complete hence full stastical analysis of the relationships between fertilizer application, utilization and livestock production is not yet possible. No attempt has been made at an economic evaluation of the data. Due to annual variability, at least three seasons should be completed before conclusions pertaining to economics are attempted.

CONCLUSION

This study has so far provided data on the effects of nitrogen fertilization of grazed pastures during a normal and a drought year. Despite annual variation in enviromental conditions, nitrogen fertilizer has been shown to increase the carrying capacity and production efficiency of grazed pastures.

IMPACT ON INDUSTRY

Results to date clearly indicate the dependancy of this type of study on seasonal conditions. At least three years data are required before these results can be assessed in terms of real biological or economic terms. The indications from this study suggest maximum beef production is achieved at a minimum fertilizer rate of 150 kg/ha, and that current pasture fertilizer recommendations are insufficient for maximum beef production.

ACKNOWLEDGEMENTS

Funding was provided by the Saskatchewan Agricultural Research Fund, Agriculture Canada Operating Grant, Imperial Oil Limited., The Outlook Water Users Association and a Hooke-Hantleman Trust Award from the University of Saskatchewan, College of Agriculture.

Table 1. The effect of nitrogen fertilizer application on animal grazing days, total liveweight production and total forage production.

FERTILIZER APPLICATION RATE kg N/ha	ANIMAL GRAZING DAYS days/ha		TOTAL FORAGE PRODUCTION kg/ha		TOTAL LIVEWEIGHT PRODUCTION kg/ha		FEED UTILIZATION RATIO[1] kg/kg	
year	83	84	83	84	83	84	83	84
0	159	107	3976	1723	119	68	33.3	25.7
50	210	123	4903	1932	147	93	33.4	20.8
% above control	32	16	23	12	23	38		
100	255	137	5687	1874	191	80	29.8	23.5
% above control	60	29	43	8	60	18		
200	280	152	4730	2404	182	104	25.9	23.2
% above control	76	42	19	39	53	54		

1) Ratio of kg forage produced : kg liveweight produced

Table 2. The effect of nitrogen fertilizer application rates on fall soil nitrogen levels.

FERTILIZER APPLICATION RATE (kg-N/ha)	DEPTH (cm)	NO_3-N (mg/kg) 1983	1984
0	0 - 15	3	3
	15 - 30	2	2
	30 - 60	1	1
50	0 - 15	15[a]	5
	15 - 30	5	4
	30 - 60	2	3
100	0 - 15	9	9
	15 - 30	11	5
	30 - 60	8	3
200	0 - 15	7	12
	15 - 30	19	34
	30 - 60	5	15

a) Probable contamination, replicates were 2 and 28.

3-82-86

FERTILIZER REQUIREMENTS OF GRAZED SEEDED GRASS PASTURES AND THE EFFECTS ON NUTRITION AND PRODUCTION OF BEEF CATTLE AND SUBSEQUENT PERFORMANCE ON WINTER FEED.

R.D.H. Cohen and S.B.M. Wright

ABSTRACT

Four levels of nitrogen fertilizer (0, 50, 100 and 200 kg N/ha) were applied to two replicates of a 32 year old brome (Bromus inermis)/ crested wheatgrass (Agropyron cristatum) pasture. The pastures were grazed by 40 tester animals at 2.5 heifers/ha and additional 'put and take' animals to allow uniform utilization of pasture.

Soil samples were collected before fertilization and at the end of the grazing season. Every two weeks, heifers were weighed and pasture quality, availability and utilization determined.

The number of animal grazing days (AGD), total liveweight production (TLP) and total forage production (TFP) increased curvilinearly with increased fertilizer application. Maximum AGD (292 days) occurred at 200 kg N/ha, TLP (200 kg/ha) at 150 kg N/ha and TFP (5659 kg DM/ha) at 120 kg N/ha.

BACKGROUND AND OBJECTIVES

Grazed pasture is a valuable resource for the cattle industry in Saskatchewan and the indications are that this resource is being inefficiently utilized. This is primarily because inadequate levels of soil nitrogen restrict plant growth and nutritive value and consequently reduce both the carrying capacity of the pasture lands and the amount of beef produced from them. While McCartney and Robertson (1982) have indicated that fertilizer applications of 90 kg N/ha are economic on depleted community pastures in the northern agricultural zone, their experiment with a single level of nitrogen fertilizer does not allow for the assessment of biological and economic optima for fertilizer use.

The objectives of this project were:

1) To determine the biological and economic responses of grazed pastures to applications of nitrogen fertilizer.

2) To determine the effects of nitrogen fertilization of grazed pasture on the nutrition and production of beef cattle.

3) To determine the effect of nitrogen fertilizer on the efficiency of utilization of grazed pasture.

EXPERIMENTAL METHOD

The project commenced in spring 1983 on a 32 year old brome (Bromus inermis)/crested wheatgrass (Agropyron cristatum) pasture at the Termuende Research Station, Lanigan. Soil samples were collected from a sixteen hectare block which was then spiked with a cultivator on May 3. The area was divided into eight, two hectare pastures and applications of 0, 50, 100 or 200 kg N/ha were applied on May 4 to each of two replications.

The experimental animals were from a group of 116 yearling heifers. All heifers were exposed to Angus bulls over a thirty-two day breeding period ending June 21. Following breeding, 40 tester animals were chosen from a group of purebred herefords and randomly assigned within weight strata to the eight test pastures. Tester animals were weighed, fasted overnight, reweighed and put on pasture June 28.

Animal production was determined using a put and take grazing system. Tester animals stocked at 2.5 heifers/ha were used for liveweight gain calculations and additional 'put and take' animals were grazed on the pastures to increase utilization on the more productive pastures. Increases in stocking rates due to the 'put and take' animals were incorporated into the 'total liveweight production' calculations for the pastures.

The tester animals were weighed every two weeks, and on alternate weeks measurements of forage quality, availability and utilization were obtained by sampling inside and outside of six exclosure cages in each pasture. Soil samples were collected again in October. Precipitation was recorded at the test site from May 1.

RESULTS AND DISCUSSION

The data reported are preliminary and should be interpreted with caution.

Season grazing was terminated on September 7 for a grazing period of 71 days. At this point it was estimated that available forage would not allow the test animals to maintain their liveweights over the next 14 day weigh period. Rainfall for the period May 4 to September 11 was 337 mm.

The rates of animal liveweight gain were similar for all fertilizer treatments at 0.7 kg/head/day, however the stocking rates showed a marked treatment effect (Table 1). Animal grazing days per hectare (AGD) increased curvilinearly with increased fertilizer application (X kg N/ha). This relationship (Figure 1) was best described by a quadratic equation with a residual standard deviation (RSD) and correlation coefficient as follows:

$$ADG = 157.9 + 1.27X - 0.003X^2 \quad (RSD \pm 6.29;\ R = 0.99;\ P<0.001) \quad (1)$$

Total Liveweight Production/ha (TLP) (Table 1) also increased curvilinearly with increased fertilizer application (Figure 1) and was best described by the quadratic equation:

$$TLP = 115.5 + 1.01X - 0.003X^2 \quad (RSD \pm 16.02;\ R = 0.91;\ P<0.05) \quad (2)$$

Total Forage Production (TFP) was estimated from the sum of differences between cuts taken inside and outside the exclosure cages. Production ranged from a low mean of 3976 kg DM/ha on the control pastures to a high mean of 5687 kg DM/ha on the 100 kg N/ha treatment, however, the data were highly variable between replicates (Table 2). Causes of this variability which are associated with sampling technique will be investigated in 1984.

Regression analysis of mean TFP data showed a high, but non significant, correlation with fertilizer applications as follows:

$$TFP = 3919 + 28.9X - 0.12X^2 \quad (RSD \pm 199.8;\ R = 0.99;\ P>0.05 \quad (3)$$

From equations 1, 2 and 3 it can be calculated that maximum AGD occurs at 200 kg N/ha (292 days), TLP at 150 kg N/ha (200 kg/ha) and TFP at 120 kg N/ha (5659 kg DM/ha). This suggests a benefit from fertilizer to the grazing animal over and above that obtained from increased forage production. In 1984, additional studies will include an evaluation of the effects of fertilizer on the nutritive value of grazed herbage using heifers fistulated at the esophagus.

Pasture sampling methods were developed but exclosure cage design and sampling techniques require refinement during 1984. Pasture utilization in 1984 will be determined by grazing exclosure methods and by direct measurement of herbage intake by cattle using esophageal fistulation and fecal marker techniques.

The analyses of soil samples taken April 29 before fertilization (Table 2) indicated a deficiency of nitrogen and phosphorus in the soil, while potassium and sulfur were more than adequate for good pasture growth. Analyses of soil samples collected at the end of the grazing period, October 12, 1983, indicate only small residual levels of NO_3-N in the fertilized soils and no effect of fertilizer on other parameters (Table 3).

Table 2. Mean soil analyses before fertilizer application, March 29, 1983.

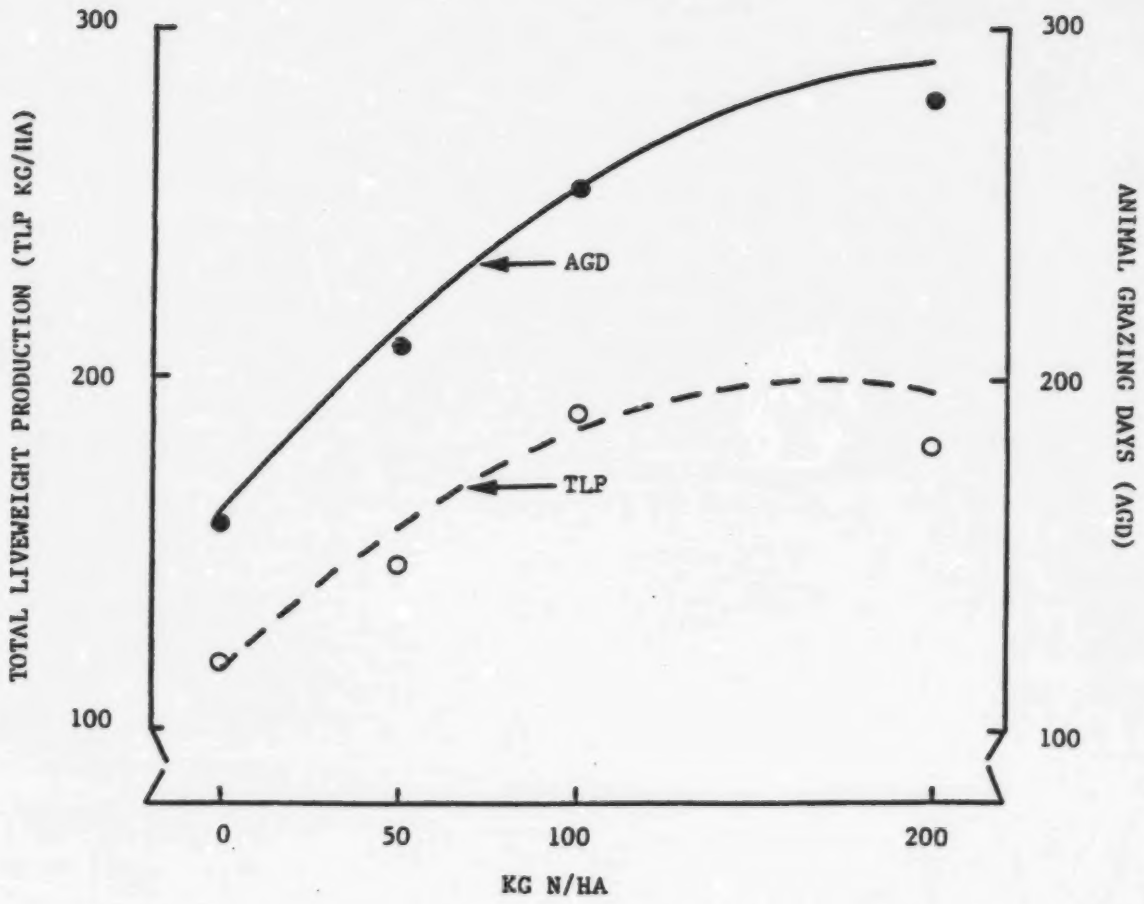
Depth (cm)	H_2O (%)	pH	NO_3-N	P	K	SO_4-S
			(mg/kg)			
0-15	15.3	7.9	3	7	244	7
15-30	12.9	8.0	1	6	183	6
30-60	10.0	7.9	1	5	156	> 12

Table 3. Soil analyses at the end of the grazing season, October 12, 1983.

Depth (cm)	Fertilizer (kg/ha)	H_2O (%)	pH	NO_3-N	P	K	SO_4-S
				(mg/kg)			
0-15	0	12.0	7.2	3	5	195	9
	50	12.2	7.5	15	3	213	9
	100	11.0	7.4	9	6	203	5
	200	12.5	7.1	7	4	160	6
15-30	0	7.3	7.2	2	2	120	5
	50	9.6	7.7	5	3	141	7
	100	7.2	7.9	11	2	140	5
	200	7.2	7.4	19	1	108	6
30-60	0	6.8	7.5	1	4	93	8
	50	7.4	8.0	2	2	94	8
	100	7.4	8.0	8	2	108	4
	200	6.2	7.6	5	2	99	7

Table 1. The effect of fertilizer on the number of animal grazing days, total liveweight production and total forage production.

Rep	Fertilizer applied (kg N/ha) 0		50		100		200	
	1	2	1	2	1	2	1	2
Animal grazing days/ha	159.1	159.1	210.0	210.0	260.9	248.2	273.6	286
Mean	159.1		210.0		254.6		279.7	
% above control	-		32		60		76	
Total liveweight Production (kg/ha)	127.3	111.4	147.0	147.0	182.6	198.5	164.2	200
Mean	119.4		147.0		190.6		182.4	
% above control	-		23		60		53	
Total Forage Production (kg DM/ha)	3612	4339	5732	4074	6822	4551	5060	43
Mean	3976		4903		5687		4730	
% above control	-		23		43		19	


300
200
100
TOTAL LIVEWEIGHT PRODUCTION (TLP KG/HA)
AGD
TLP
0
50
100
200
KG N/HA
ANIMAL GRAZING DAYS (AGD)